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Canadian Society of Civil Engineers.

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TRANSACTIONS.

N.B.—This Society, as a body, does not hold itself responsible for the facts and opinions stated in any of its publications.

(To be read on Thursday, the 13th or 27th February.)

(N.B.—All members are particularly requested to send to the Secretary records of any tests of Canadian cements with which they may be acquainted, with remarks on the mode of manufacture and the uses of such cements.)

THE MANUFACTURE OF NATURAL CEMENT,
as carried on at the works of the Napanee Cement Co. (Limited), at Napanee Mills, in the County of Lennox and Addington, Ont.

By M. J. Butler, M.Can.Soc.C.E.

The Geological Report of the State of New York, 1839, contains an analysis of "Maulius Hydraulic Limestone," stating at the same time: "This stone belongs to the same bed which yields the hydraulic cement obtained near Kingston, Upper Canada."

As the only bed of hydraulic limestone found near Kingston is the one at Napanee Mills, there can be no doubt but that it is the one referred to.

It was not, however, until the year 1867 that anything was done towards working the bed, when Mr. H. M. Wright, a lumber merchant, acquired the quarry and had one or two kilns built at the quarry site. The mill for grinding the stone and the cooperage works for the manufacture of the barrels were built at Napanee, six miles distant, where convenient facilities for shipping by boat or rail were to be had, the burnt rock being teamed from the quarry to the mill.

Messrs. Wright & Co. produced a fairly good quality of cement, supplying the local demand for a cement for cellar floors, cisterns, dams, etc.; they sold out to George Lasher & Co. in 1874, who carried on the cement and lime business for six years.

In 1880 the Napanee Cement Co. (Lmtd.) was incorporated, buying the mill and cooperage works at Napanee, and arranging with Mr. Lasher to supply the burnt rock to the mill at a stated price per ton. This arrangement proved very unsatisfactory to the Cement Co. In 1883 the cement was so very bad, that it was felt that something had to be done to improve the quality.

The writer was requested by the manager to make an examination of the quarry, mill, method of burning, grinding, etc. On examination it was found that the stripping (consisting chiefly of a loose shale) and all other rock, just as it came handy, without regard to size, quality or anything else, was alike dumped into the kilns to be alike burned for about 24 hours. At the mill the grinding was loosely and carelessly done, one burrstone alone turning out 130 barrels per day.

A report was made setting forth the facts and advising a careful test of each layer in the quarry by itself; some to be underburnt, some to the point of vitrification, some intermediately. Attention was particularly requested to getting the grinding as fine as possible so as to not retain more than ten per cent. on a 2,500 mesh. The purchase of a testing machine was advised. It was thought that in this way the best cement might be had that the quarry was capable of producing. Some time in 1884 the manager died; after his death the companies was re-organized. A new manager of works was secured, and the work of real improvement was energetically taken hold of, and is still being carried on.

In 1886, owing to the construction of the Napanee, Tamworth and Quebec Railway, which passes close to the quarry, it was thought best to build a new mill at the quarry site; before doing so, however, the Cement Co. had a series of careful and thorough tests of each and every layer in the quarry made by an expert in the cement business from the United States; his report advised the using of certain layers aggregating some 5½ feet in depth.

The mill is built of stone 40 x 80 feet, three stories in height with an engine and boiler room 40′ x 40′ also of stone, one story in height, and contains an engine of 40 H. P. and two horizontal tubular boilers.

South of the main building and 70 feet distant is the stave preparing mill 30′ x 80′, built of brick. East of the main building 100 feet is the barrel factory 30 ft. by 50 ft., also of brick.

The kilns lie about 200 ft. north of the main building, of which there are three. They are of the continuous burning type, with two doors for firing purposes and one door for withdrawing the charge.

Process of Manufacture:—The rock is broken into pieces of tolerably uniform sizes, averaging about $\frac{1}{10}$ to $\frac{1}{12}$ of a cubic foot each, loaded in carts and hauled to the top of the kilns and dumped into them.

Burning:—There are three continuous kilns fired on two sides; each kiln holds sufficient rock to make about 150 barrels of cement. The charge is withdrawn about every eight hours, depending somewhat on the weather, the foreman and attendant judging from the appearance of the stone the sufficiency of the burning. It requires about half a cord of soft wood to each ton of cement.

Manufacture of the burnt rock:—As fast as the charge is withdrawn at the base of the kiln, it is loaded into an iron car, and hauled by a wire rope up an incline to the 3rd floor of the building, here it is dumped into a conical box which feeds by gravity into a rock breaker, and slowly tumbles down to the second floor where it reaches the grinders, about the size of beans.

The grinders are the ordinary French burrstones. It is then ground and passed to bolters that are at present 1,600 meshes to the square inch. A finer bolting cloth 2,500 meshes was tried, but was found to clog with the finer particles attaching themselves to the wire; the residue from the bolters is returned to the stones and reground.

Numerous tests show that a 2,500 mesh standard sieve will retain barely 10 per cent.

After leaving the grinders the cement drops on the first floor, where it is allowed to cool on an average about two weeks before being barrelled. A series of tests are made from each burning, the procedure in preparing the samples being that recommended by the Committee on cement testing of the American Society of Civil Engineers, the object of the tests being to insure a uniform article.

For convenience of reference and comparison the following tables of analysis and strength are added:

ANALYSIS OF VARIOUS NATURAL AND ARTIFICIAL CEMENTS.

Name of Brand. By whom analyzed.	Akron, N.Y. E. C. Boynton.	Buffalo, N.Y. E. F. Cox.	Milwaukee, Wis. E. F. Cox.	Utica, N.Y. G. Bode.	Louisville. E. F. Cox.	Fayettville. E. F. Cox.	Rosendale. E. C. Boynton.	A Perfect Cement.
Silicic Acid	54 77	32 86	28 11	35 43	20 66	18 22	43 11	32 00
Alumina	6 42	8 38	27 62	9 92	27 11	26 76	3 64	8 00
Lime	29 64	52 60	37 18	33 67	50 52	51 99	40 09	54 00
Magnesia	9 17	6 16	7 09	20 98	1 71	3 03	13 16	6 00
Total	100 00	100 00	100 00	100 00	100 00	100 00	100 00	100 00

Name of Brand.	An Eng. Portland.	A good Portland.	A Ger. Portland.	Maulius.	Napanee.
By whom analyzed.	Ext'd. from Henry	Reid's Treatise on	Portla'd Cement.	Dr. Maulius Smith	of Syracuse, N.Y.
Lime Ca.O	56 68	60 05	58 03	45 00	39 73
Magnesia Mg.O	0 57	1 17	2 93	18 55	18 02
Oxide of Iron $Fe^2 O^3$	....	....	11 30	11 97	10 50
Alumina $Al^2 O^3$	7 74	10 84			
Silicia $Si O^2$	22 74	24 31	21 11	19 60	26 35
Alkali Na Ho K.Ho	0 63	1 54	0 71	Trace.	....
Sulphate of Lime So_4 Ca	1 66	....	0 51	2 04	0.935
Carbonic Acid Co^2	3 50	....	0 83	2 70	2 95
Undissolved Residue	0 53	....	0 49	....	....
Water H^2O	1 99	....	0 54	0 70	....
Total	99 65	97 91	99 81	100 62	98.485

TENSILE STRENGTH OF VARIOUS BRANDS OF NATURAL AND ARTIFICIAL CEMENTS.

ALL SAMPLES ARE UNIFORMLY OF ONE SQUARE INCH SECTION.

Age of specimens, after being allowed 1 hour in air, balance of time in water.

Name of Brand.	1 Dy.	2 Dys.	1 Week	2 Weeks.	1 Month.	6 Mths.	1 year	2 yrs.	3 yrs.	Authority.	Remarks.
Louisville	72.2	78.7				150.6				Journal Assoc. Eng. Societies, page 187 Vol. V.	
Rosendale	49.0		73.0		156.0	286.0				Journal Assoc. Eng., Societies, page 187 Vol. V.	
Average of 25,000 samples of American cements	71.		92.0		145.0	282.0	290.0			Eliot C. Clark, Boston Main Drainage Works.	
Napance	50.		90.0		140.0	280.0	300.0	315		M. J. Butler. the two year old samples were from a lower grade of cement, thence do not show as great strength in proportion to age.	
Artificial *			280. not	broken	at 1 year	8 mos.	275	broke	it.	These two briquettes were composed of common lime and clay burned together and ground finely.	
" *			390. "	"	"	"	290	"			
Portland Cement.	102.		303.		412	468	494			Eliot C. Clark, Boston, Main, Drainage Works.	
Alsen & Co, Portland	170.		275.	340	467	561	690			E. J. De Smedt, Foreign, Portland.	Rep'rt District Columbia, 1885.
J. B. White	95.		200.	268	364	400				" " " "	
Giant	150.		335.		416	673	700			" " American "	
Egypt	100.		270.		355	"				" " " "	

NOTE—The two samples of artificial cement shew that it is quite possible in short time tests to get a high result from an inferior article, as these samples deteriorate with age.

It is not quite so simple a matter as it appears to properly prepare briquettes for the testing machine; to begin with, the quantity of water used exercises a most important influence, the mortar should be very stiff and be firmly pressed into the mould so as to fully exclude air, the operations should be quickly performed, the sample should rest on an impervious plate, glass being probably as good as any. After the mould is filled, it should then be struck off evenly with a trowel, and be left quietly for a short time before undertaking to remove the sample from the mould, the slightest disturbance at this stage materially interfering with the proper setting of the sample. After the sample has set in air, usually one hour being required, it should then be carefully removed from the mould and placed in water, where it should remain until the expiration of the time fixed for breaking.

Once it is placed in the testing machine the load should be applied steadily, quietly, and without jerking up to the breaking limit. Notwithstanding that every care may be exercised in the preparation and manipulation of the samples under test, it will be found that they do not break with uniformity, and it is only by taking the average of a great many samples that anything like a correct result may be arrived at.

Having secured a high tensile strength, as evidenced by the testing machine, the question is, have we a cement that is going to prove itself reliable when subjected to the test of time and the elements? Is there any connection between high tensile strength and good reliable wearing properties? Have the cements that show a high tensile strength proven themselves better under use than the natural cements? Is it not a fact that the cements which give such a high tensile strength grow brittle with age, and crack and peel off? Witness the cement walks wherever laid, the painting in any old bridge with the higher testing Portland cements, they will be found full of cracks and scales which can be readily picked off; of course, it is very hard, but brittle, whereas when we come to examine any old work laid up with the natural cements, we rarely find cracks or other signs of disintegration. The variety and extent of the works in existence, built entirely with the natural cements, show their good lasting qualities; witness the Erie Canal, the high bridge on the Croton Aqueduct, and innumerable other works of great magnitude. The writer has used in one season over 10,000 barrels of natural cement from Louisville, Milwaukee and Utica, on foundations in caissons on well work and other trying situations without an instance of failure.

At Napanee Mills, the Napanee Paper Co., Limited, put in some three or four tanks of large size, and lined them with the Napanee cement, some ten or twelve years ago; they are perfectly water-tight, the cement having set as hard as limestone rock. At Gananoque the dams and canals of the Gananoque Water Power Co. are all grouted with Napanee cement, some of it having been in use 8 or 9 years.

In 1883 the writer was present at the tearing down of an old head gate which had partially rotted out, and it became necessary to cut away some posts that had been grouted in. It actually took two good men one day to pick out a post 8" × 8" × 7 feet, showing how hard the cement had become. These dams are all water-tight, and the cement is very hard.

At Deseronto, about five years ago, the foundations for a heavy gasmeter, requiring to be perfectly water-tight, were with much misgiving on the part of the superintendent put in with a concrete composed of 2 parts sand to one of Napanee cement and three parts broken limestone, not one cent has ever been expended for repairs, and the concrete is now in first-class order without a crack. On the Grand Trunk Railway bridges, on the canals and other public works of the Government, many thousand barrels have been used, all giving good satisfaction; of course it is easier to abuse natural cement than Portland, if too much water or sand is used the mortar will be weakened. When such a record as has been above instanced can be shewn from the old cement, there is no doubt but that the present cement now being turned out is a first rate reliable natural cement, as good as can be ordinarily secured in any of the quarries in use.

E. J. De Smedt, chemist to the District of Columbia, U. S., says: "A limestone such as dolomite, containing 46 per cent. of magnesia, has been pronounced unfit for making good cement; but when the percentage of magnesia is not too large, it becomes in time just as hard as a cement containing no magnesia, with this difference, that it is somewhat slow in setting. In sea water containing magnesia such cement should be preferred, for the reason that it does not disintegrate in that water."